Stability Limits for Longitudinal Waves In a Plasma Traversed by an Ion Beam

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The dispersion equation $\varepsilon(\underline{k},\omega) = 0$ for linearized, longitudinal waves is studied for a plasma (density n_p, temperature T_p) traversed by a beam of ions (density n_b, temperature T_b, streaming velocity V_b). The system is characterized by the kimensionless parameters $n = n_b/n_p$, $\theta = T_b/T_p$, and $V = V_b \ (M/2\ T_p)^{1/2}$, where M is the common mass of the plasma ions and beam ions. A two-stream instability involving the plasma ions and beam ions, in presence of the electron background, is found, and the surfaces in the n, θ, V space corresponging to marginal stability are calculated. For given n, the plot of critical θ vs V has the shape of a resonance curve, points above its corresponding to stability, those below it to instability. Its maximum occurs at V between 1.5 and 1.7, which agrees with the phase velocity for ion acoustic waves in an equilibrium plasma; the maximum corresponding θ value is 1/9, which occurs for $n \doteq 1$. Allowing unequal temperatures in the plasma, $T_e > T_i$, enlarges the region of instability, as expected. By taking into account the relation between n_b, T_b, and V_b imposed by the beam acceleration process, stability curves in the ϕ, n plane are calculated, where ϕ is the accelerating potential for the ion beam. Preliminary results from experiments by R. Rowberg and J. M. Sellen with a beam of ions in a cesium plasma will be discussed.